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This TOP outlines the procedures for conducting sand and dust tests for vehicle mounted automatic weapons systems up to 40mm.

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Test Operations Procedure 3-4-012
AD No.: ADA425558

2 September 2004

DESERT ENVIRONMENTAL (SAND AND DUST) TESTING OF VEHICLE-MOUNTED
PRIMARY AND SECONDARY AUTOMATIC WEAPON SYSTEMS, UP TO 40MM

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1. SCOPE.

This TOP provides test procedures that will enable determination of the basic and relative performance capabilities of vehicle-mounted, small caliber weapon (up to 40mm) systems under extreme sand and dust desert environmental conditions. Functioning performance of weapon systems can be impaired by ingestion and deposits of sand and dust thrown up by their own, preceding, or adjacent vehicles, when moving in desert terrain. Prevailing winds, depending on velocity and direction, can aggravate or ameliorate the effect of dust clouds and plumes. Each tracked or wheeled vehicle design has its own individual dust plume-producing

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characteristics. The characteristics vary with the relative positions of wheels with respect to the hull, the shape of wheel wells, the extension of tracks forward and rearward, and efficiency of fenders, shrouds, shields and guards. The flow can also be influenced by engine exhaust, depending on its location(s). Sand and dust infiltrates to the inside of the vehicle not only through open hatches, but also through ventilators, fired case and link ejection chutes, and mantlet or rotor gaps. Internal pressurization can combat sand and dust penetration, whereas vacuum caused by drawing engine air from the crew compartment and turret can increase it. The adverse effects of sand and dust on gun functioning, and exposed sliding and rubbing feed components and mechanisms can be quite severe. Overheated electronic components can result in failures or altered values affecting gun and turret control systems.

The test scenario provides for running a test vehicle, following another similar vehicle, on a sand and dust course with firing at specified intervals. Weapon system functioning, as affected by sand and dust, is evaluated as the principal measure of performance under these conditions.

The weapons and systems covered include developmental, standardized, product-improved, modified, domestic, or foreign material. The weapons and weapon system types covered by this TOP include: Primary turret or cupola-mounted automatic guns, grenade launchers, and machine guns up to and including 40mm; secondary weapons such as cupola, ring/skate, ball, fixed, pedestal, and coaxial-mounted automatic guns and machine guns; and auxiliary weapons such as firing port weapons, ranging weapons, and smoke and flare launchers. Weapon systems include the support subsystems such as weapon feed and ejection systems, fire control, sights, and turret/mount crew provisions. Stowed/carried individual weapons such as rifles, carbines, submachine guns, pistols, hand-held grenades, flare launchers, and guns are covered but are hand-fired from the vehicle.

The procedures in this TOP apply only to the previously identified weapon systems under conditions of an extreme sand and dust environment. A general desert environmental test takes into account additional aspects of desert conditions including protracted heating effects, solar radiation and low humidity, shock and vibration, and endurance and reliability over several types of terrain. See TOP 2-4-001.^{1*}

* Superscript numbers/letters correspond to those in Appendix E, References.

2. FACILITIES AND INSTRUMENTATION.

2.1 Facilities.

<u>Item</u>	<u>Requirement</u>
Combined Test Course and Firing Range**	<p>Test course that has sand and dust with hard, abrasive physical characteristics. If a test system will function satisfactorily under these conditions, it is likely to do so under almost all other sand and dust environments. ***</p> <p>The test course should have a firing range that will safely accommodate the established range safety fan of the test weapon system through its full range of evaluation. If the firing site is located separately from the test course, sand and dust accumulated on the test item may be lost in transit to the firing site.</p> <p>Mound or ramps to enable positioning the test vehicle for firing at 30-degree pitch forward and rearward and 15-degree cant right and left, as well as vehicle level.</p>
Vehicle	<p>A vehicle, generally of the same type (i.e., wheeled or tracked) as the vehicle under test to precede this vehicle on the test course to best simulate convoy operation.</p>
Electronic Analysis System	<p>Standard electronic analysis equipment, including simplified test equipment STE/ICE if provided, for the test vehicle and weapons systems.</p>

** The MilePost 70 Dust Course at Yuma Proving Ground is a primary example of such a test course.

*** The principal characteristic of sand and dust having the greatest adverse effect on mechanical functioning is a high percentage (at least 30-35%) of quartz. The balance may be composed of clay, minerals, carbonates, or granitic and volcanic origin. The majority of the

airborne particles (more than 75%) will range in size from 10 to 30 microns. The upper limit of particle size raised by tracked and tire-equipped vehicles is in the range of 74 to 78 microns. In the fine fraction, particle sizes range from 0.5 to 2.0 microns, generally of clay composition. It is desired that the quartz particles be sharply angular, with angularity increasing with decreasing particle size, and not rounded from protracted weathering.

2.2 Instrumentation.

<u>Devices for Measuring</u>	<u>Measurement Accuracy</u>
Time	± 0.5 min or $\pm 2\%$ of the true value, whichever is larger
Road Speed (speedometer)	0-50 km/hr: ± 0.5 km/hr 51-100 km/hr: ± 1.0 km/hr
Engine speed (transducer)	0-3000 r/min: ± 5 r/min 3001-6000 r/min: ± 10 r/min
Pressure	$\pm 4\%$ full range at any value, normally 152.4 cm water (-14.95 kPa) for air cleaner restrictions)
Accrued mileage (odometer)	± 3 km
Component temperature (temperature transducer)	$\pm 3^{\circ}\text{C}$
Size of airborne dust particles	U.S. Standard Sieves No. 60 through 200 and colter counter
Soil Moisture Content	Measured by Weight Change upon drying of sample. Method accuracy estimated at 0.1%.
Meteorological conditions:	
Ambient temperature	$\pm 3^{\circ}\text{C}$ of true value
Relative humidity	$\pm 2\%$
Wind speed	± 3 km/hr
Wind direction	$\pm 10^{\circ}$
Barometric pressure	± 0.4 kPa

<u>Devices for Measuring</u>	<u>Measurement Accuracy</u>
Visual Acuity	N/A Use Landolt ring targets for measuring deterioration in visual acuity through telescopic and periscopic sights, rangefinders, etc.
Push-pull scale for measuring gun belt pull, latching and unlatching efforts, etc.	As required.
Load cell with ammunition belt adapters and recorder for measuring in-belt tension forces to determine feed system drag or resistance or gun belt pull.	As required.
Electronic restriction warning tone into driver's ear phones.	As required.

3. REQUIRED TEST CONDITIONS.

3.1 Facilities.

a. Till and disk the test course surface prior to test initiation. Ensure the test course is as dry as possible (soil moisture content below 4%) so that test vehicles will generate maximum sand and dust clouds needed during the test phase.

b. Ensure the crew and equipment of the vehicle with the test weapon, and crew and the lead vehicle are properly prepared in accordance with the pertinent instructions for manuals for desert operations, with particular emphasis on filters and lubrication. Guidance in TOPs 2-4-001, 1-1-006², 2-2-819³, and 2-4-002⁴ for automotive test aspects.

3.2 Test Weapon System.

a. Ensure the test vehicle, weapons and subsystems are fully serviceable and are prepared IAW pertinent technical manuals (TMs), lubrication orders (LOs) or special instructions for desert operations, if available. Proper lubrication is crucial to gun functions, particularly in a desert environment; however, instructions contained in specific weapon system manuals for desert operations are often inadequate. Lubrication instructions should not be changed from what is specified in the appropriate TM or LO unless authorized by the test sponsor. Experience

has demonstrated that heavy lubrication provides the best preparation for a sand and dust environment. Unless otherwise specified, guns should be heavily treated with Lubricant, Semi-fluid, Small Arms (LSA) oil. This semi-fluid oil has the advantages of high retention and excellent lubricating characteristics, which also provide for a good washing action. These features far outweigh any increase in sand and dust adhering to an oily surface. A light coat of lubricant would soon be soaked up by sand and dust, leaving components gritty and dry, thus radically increasing friction between adjacent surfaces. Obvious lubrication discrepancies should be pointed out to the test sponsor prior to starting the sand and dust test.

b. Dry (unloaded) function cycle the installed weapon and all subsystems to establish that functioning is normal.

c. Finally, fire the complete weapon system at the test site with the vehicle level before starting the first test run. Firings will primarily be functional only; however, a limited amount of accuracy firing should be made, if possible, to check out the entire fire control system. Use all firing modes, feed selects, and the full range of turret or other mount elevations, as applicable. Reload the weapon systems with a full compliment of ammunition in preparation for the first test run. Firing procedures done at the start of the sand and dust test should be identical to those done during or after the actual test runs (specified in paragraph 4.1) to allow direct comparison of results.

3.3 Test Controls.

a. Use standard ammunition (other than high explosive whenever possible), preferably target practice/tracer or ball/tracer, combat or equivalent combat load, for safety of the operation and to avoid range contamination.

b. Ensure adequate engine and ventilator air cleaner filters are available to support the test vehicles in order to minimize down time for vehicle maintenance.

c. Maintain uniformity of test conduct, i.e., speeds of approximately 25 to 35 km per hour, turning rates, acceleration/braking rates, etc., as much as possible so that results can be duplicated and different weapon systems' performance can be compared.

d. Carefully document all system malfunctions (particularly gun stoppages) with a complete description, keeping in mind that they will have to be evaluated for cause. It is particularly important to determine if they are sand and dust related, represent a failure that has occurred before under moderate conditions, or a failure that could occur under any climatic conditions. Perhaps the failure was due to a basic design fault, production defect, or was caused or influenced by another failure.

4. TEST PROCEDURES.

4.1 Method.

The basic test scenario provides for a 240 km run of the test vehicle under conditions that represent traveling in a column, in convoy on unpaved desert roads or trails, or in column through mine fields or cross-country while subjecting the vehicle to the equivalent of intermittent blowing sand and dust. It is essential that the vehicle and weapon system be prepared and configured in a ready or stand-by mode normally expected for convoy travel in a combat environment. 'Ready' in this context indicates that the vehicle should be loaded with a full complement of ammunition, Basic Issue Items (BII), Authorized Items List (AIL), and fuel. Where safety or other considerations restrict or prohibit this 'ready' condition, a dummy payload may be substituted. User guidance may be required to establish this configuration unless clearly indicated in the appropriate vehicle TMs or applicable field manuals. It is critical that the weapon systems be prepared for travel IAW approved user operational mode doctrine for operation in the sand and dust environment. Whether or not a gun muzzle cover is to be put on the gun, or a vehicle hatch is to be open or closed, may prove to be crucial in the overall performance of the vehicle/weapon system in the sand and dust test. The test vehicle will normally be preceded by a lead vehicle, similar in size/type to the test vehicle, on the test run. The test vehicle should stay as close to the lead vehicle as safely possible, normally a 10 to 50 meter interval. Other vehicle or weapon systems' modifications to improve performance in the sand and dust environment (e.g., use of gun tape or similar methods for sealing purposes) should not be made unless authorized by applicable operating instructions or appropriate user guidance. The lead vehicle will be used unless otherwise specified. Caution must be taken by the crew of the trailing vehicle not to get too close to the lead vehicle to avoid a collision due to poor visibility. Crew will review all available safety procedures prior to going into the test. Radio communication will be maintained at all times between the running vehicles with visual markers/lights, etc., used to maintain safe distance between the test vehicles. Vehicles will travel at the maximum safe speed based on test director evaluation of existing test course conditions and weather.

a. The test vehicle is driven to the appropriate firing range and stopped to fire the test weapon(s) at 40 km intervals for six cycles. Each weapon system will fire enough rounds at each halt to ascertain performance through its full range of elevation, various firing rates, feeds, modes, controls, and vehicle orientation. These firings will include a limited amount of accuracy firing, if possible. A full complement of ammunition carried on-board the vehicle in the main and secondary weapons ready boxes may be fired during the test. Also, a portion of the stowed ammunition from the vehicle may be used to reload the weapons for continued firing during the 240 km run. The total number of rounds fired and the number fired in each of the six halts will vary depending on the amount of ammunition carried on the vehicle. The entire ammunition

load (ready and stowed) need not be fired, but a portion of the stowed ammunition should be fired to evaluate the reloading of the weapons during operation in the sand and dust environment.

b. The 240 km test should be successfully completed without scheduled maintenance and with unscheduled maintenance held to a minimum. This test scenario is intended to represent, not an average, but a long combat day under the most severe sand and dust conditions likely to be encountered in a desert environment. Under conditions of rapid advance or retrograde action, major system maintenance would not be possible during short halts. Major maintenance consisting of complete cleaning of weapons, feed chute, ammunition boxes, and belted ammunition for primary automatic weapons systems and coaxial machine guns can take from 2 to 4 hours. This does not include other vehicle maintenance and cleaning of firing port weapons and personal weapons. Minimal gun maintenance action that is feasible is usually limited to clearing gun stoppages by taking immediate action and reloading. Immediate action generally consists of moving or changing the bolt to the rear position, either electrically or manually, to: remove a misfired round; allow a failure-to-eject case to fall out; correct a short recoil, or chamber a fresh round. Allowable times to clear stoppages generally are 10 to 20 seconds, with a limit on the number permitted. It is considered that an additional 10 seconds taken to squirt more lubricant into the gun mechanism does not constitute excessive maintenance in a severe sand and dust environment. However, no disassembly or cleaning should be required, because it would take too long to accomplish under combat mission requirements.

c. For armored vehicles, during test, the driver's hatch should be partially (popped) or fully open (fully latched) to provide optimum visibility. The driver's hatch may remain closed if the vehicle is equipped with a thermal viewing device at the driver's position (e.g., Driver's Thermal Viewer) that permits adequate vision of the lead vehicle so that the 10 to 50 meter interval between the lead and test vehicles can be safely maintained. The remaining hatches may be open or closed depending on the required configuration for operation in the sand and dust environment. Use of compartment blowers, fans, or ventilators is optional depending on whether or not their use is considered beneficial or detrimental to the crew. Non-armored vehicle tests will be configured in a similar fashion. User guidance may be required to establish proper test configuration so that sand and dust tests be as realistic as possible to simulate actual road march or convoy movements.

d. Before loading, manually and/or power operate the turret, dry cycle the weapon, and operate modes, feed selects, etc., as applicable. Operate turrets, cupolas, ring, and chute mounts through their full range of elevation and deflection. All weapon systems will be fully loaded, and be safe for the runs on the test course. Pyrotechnic smoke launchers will be fully loaded and safe.

4.2 Firing Scenarios.

a. Fire the primary automatic guns, coaxial machine guns and mounted grenade launchers IAW the appropriate or modified example schedules in Tables 1, 2, or 3. Adjust the total rounds fired, the rounds fired per 240 km, and the burst length according to the test system ammunition ready box capacity. Fire from the small cupola, ring, skate or pedestal machine gun mounts in a like manner. Ammunition totals, rounds per 40 km, and burst lengths fired will be established, considering not only the capacity of the ammunition ready box but also the total quantity carried on the vehicle. A machine gun ready box may carry up to 6,000 rounds. Select the appropriate schedule or modify the example schedules in Tables 4 or 5.

b. (Optional, seldom performed) Fire the firing port weapons IAW the appropriate schedule or modify the firing schedule example at Table 6. Adjust the total rounds fired, rounds fired per 40 km and burst length according to weapon magazine capacity (typically 30 to 200 rounds), depending on whether box magazine or belt fed. Also consider the total number of rounds carried on the vehicle and divide by six for the number of rounds to fire per 40-km cycle per firing port weapon.

c. The number/distribution of ranging/spotting rifle firings are generally based on multiples of primary large caliber rounds (over 40-mm) carried on the vehicle. Allow for three to five ranging/spotting rounds per main round carried on the vehicle, as well as the total spotting/ranging rounds carried. The system design and firing procedures will determine the modes of fire such as whether the rifle is fired single shot or in full automatic bursts. If the main weapon is to be tested also, then a combined alternating firing schedule will be used. Divide the total ranging/spotting rounds to be fired by six for the rounds fired per cycle.

d. The number of pyrotechnic and smoke grenade launchers fired per cycle is determined by dividing the total number of rounds carried into six groups. Ensure that all tubes of multiple tube launchers are fired. Leave the muzzle covers off for all runs, unless they are designed to be shot off or can be removed from inside the vehicle.

e. Fire individual hand/shoulder-fired weapons, such as: pistols, rifles, sub-machine guns, squad automatic weapons, light machine guns, and grenade launchers IAW the appropriate abbreviated schedules from TOP 3-2-045⁵, Tables 4, 5, 6, and 7. The total number of rounds fired will be based on the rounds per weapon carried in the vehicle, including that which is carried by the individual personnel. Divide the totals by six for the number of rounds fired per 40-km cycle.

4.3 Support/Auxiliary Equipment.

a. While conducting the firing tests, refer to the preparation-for-test checklist located at Appendix A. Continue to check and evaluate those areas during firing and in the other turret operational areas as well. Evaluate the effects of sand and dust on maintenance requirements and tasks.

b. At each halt before firing, use landolt ring targets to determine the target obscuration effects of accumulated sand and dust on telescope, periscope and optical range finder lenses. Tests should be run with the targets having rings of graduated sizes, at the same range for each check, to include one before the first test run. The ring gaps should be rotated to avoid memory input after each check.

c. If cloth or plastic covers are provided for the guns or feed chutes, they should not only protect the materiel from excessive sand and dust contamination, but should be quick and easy to open and close or to remove and replace. Determine from appropriate manuals or user representatives if the gun covers are designed to be anchored in such a manner, particularly for externally-mounted flexible guns or launchers, so that the covers will not be lost or discarded and are more likely to be used. Muzzle covers must be capable of being shot off without damage to barrel or muzzle attachment. If this has not yet been determined, fire through at least three of them after completion of all other firing tests. Inspect for damage to the barrel or muzzle attachment.

d. Evaluate operation and efficiency of fans/blowers. Toxic fume tests should have previously been conducted on the vehicle/weapon system to evaluate the ability of the ventilation fan/blower to exhaust gun gases.

Table 1. Example of Firing Schedule for Bradley Fighting Vehicle System (BFVS), a 240-km/300-round IFV, 25-mm Primary Weapon Test.

<u>Cycle No.</u>	<u>Vehicle Position</u>	<u>No.</u>	<u>Burst Length</u>	<u>Feed</u>	<u>Mode</u>	<u>Firing Trigger</u>	<u>Gun Elevation</u>
1	Level	1	5	AP	SS	RHG	Min
		2	10	HE	LO	LHG	0
		3	10	HE	HI	MG	Max
		4	5	AP	SS	C	Max
		5	10	HE	LO	RHG	0
		6	10	HE	HI	LHG	Min
2	Pitch Forward 30°	1	5	AP	SS	RHG	Min
		2	10	HE	LO	LHG	0
		3	10	HE	HI	MG	Max
		4	5	AP	SS	C	Max
		5	10	HE	LO	RHG	0
		6	10	HE	HE	LHG	Min
3	Pitch Rearward 30°	1	5	AP	SS	RHG	Min
		2	10	HE	LO	LHG	0
		3	10	HE	HI	MG	Max
		4	5	AP	SS	C	Max
		5	10	HE	LO	RHG	0
		6	10	HE	HI	LHG	Min
4	Cant Left 15°	1	5	AP	SS	RHG	Min
		2	10	HE	LO	LHG	0
		3	10	HE	HI	MG	Max
		4	5	AP	SS	C	Max
		5	10	HE	LO	RHG	0
		6	10	HE	HI	LHG	Min
5	Cant Right 15°	1	5	AP	SS	RHG	Min
		2	10	HE	LO	LHG	0
		3	10	HE	HI	MG	Max
		4	5	AP	SS	C	Max
		5	10	HE	LO	RHG	0
		6	10	HE	HI	LHG	Min
6	Level	1	5	AP	SS	RHG	Min
		2	10	HE	LO	LHG	0
		3	10	HE	HI	MG	Max
		4	5	AP	SS	C	Max
		5	10	HE	LO	RHG	0
		6	10	HE	HI	LHG	Min

- NOTES: 1. Run 40 kilometers before each firing cycle for a total of 240 kilometers.
2. All firings are with the gun forward over the front of the vehicle.
3. When the vehicle is pitched rearward, limit maximum gun turret elevation to 30 degrees for a total elevation of 60 degrees.
4. Codes and abbreviations are listed at Appendix D, Page D-8.

Table 2. Example of Firing Schedule for USMC LAV-25, 240-km/ 210 Round, Primary Weapon
(M242 25 mm Gun) Test.

<u>Cycle No.</u>	<u>Vehicle Position</u>	<u>No.</u>	<u>Burst Length</u>	<u>Feed</u>	<u>Mode</u>	<u>Firing Trigger</u>	<u>Gun Elevation</u>
1	Level	1	5	AP	SS	G	Min
		2	10	HE	LO	C	Min
		3	5	AP	LO	C	Max
		4	10	HE	HI	G	Max
		5	5	HE	SS	GM	0
2	Pitch Forward 30°	1	5	AP	SS	C	Min
		2	10	HE	LO	G	Min
		3	5	AP	LO	G	Max
		4	5	HE	SS	GM	0
		5	10	HE	HI	C	Max
3	Pitch Rearward	1	10	HE	HI	C	Max
		2	5	AP	LO	G	Max
		3	10	HE	LO	G	Min
		4	5	AP	SS	C	Min
		5	5	HE	SS	GM	0
4	Cant Left 15°	1	5	HE	SS	GM	Max
		2	10	HE	LO	C	0
		3	10	HE	HI	C	0
		4	5	AP	SS	G	0
		5	5	AP	LO	G	0
5	Cant Right 15°	1	5	AP	LO	C	Max
		2	5	AP	SS	G	Min
		3	10	HE	LO	G	Max
		4	10	HE	SS	C	0
		5	5	HE	SS	GM	Min
6	Level	1	5	AP	SS	G	0
		2	10	HE	LO	G	Max
		3	5	HE	SS	GM	0
		4	10	HE	LO	C	Max
		5	5	AP	SS	C	Min

- NOTES: 1. Run 40 kilometers before each firing cycle for a total of 240 kilometers.
2. All firings are with the gun forward over the front of the vehicle.
3. When the vehicle is pitched rearward, limit maximum gun-turret elevation to 30 degrees for a total elevation of 60 degrees.
4. Codes and abbreviations are listed in Appendix D, Page D-8.

Table 3. Example of Firing Schedule for a 240-km/400-round 7.62-mm Coaxial-Mounted Machine Gun (M240/240C) Test.

<u>Cycle No.</u>	<u>Vehicle Position</u>	<u>No.</u>	<u>Burst Length</u>	<u>Firing Trigger</u>	<u>Gun Elevation</u>
1	Level	1	15	G	0
		2	15	C	Min
		3	15	G	0
		4	15	C	Max
		5	6	GM	0
2	Pitch Forward 30°	1	15	C	0
		2	15	G	Min
		3	15	C	0
		4	15	C	Max
		5	6	GM	0
3	Pitch Rearward 30°	1	15	G	0
		2	15	C	Min
		3	15	G	0
		4	15	C	Max
		5	6	GM	0
4	Cant Left 15°	1	15	G	0
		2	15	G	Min
		3	15	C	0
		4	15	G	Max
		5	6	GM	0
5	Cant Right 15°	1	15	G	0
		2	15	C	Min
		3	15	G	0
		4	15	C	Max
		5	6	GM	0
6	Level	1	15	C	0
		2	15	G	Min
		3	15	C	0
		4	15	G	Max
		5	10	GM	0

- NOTES: 1. Run 40 kilometers before each firing cycle for a total of 240 kilometers.
 2. All firings are with the gun forward over the front of the vehicle.
 3. When the vehicle is pitch rearward, limit maximum gun - turret elevation to 30 degrees for a total elevation of 60 degrees.
 4. Codes and abbreviations are listed at Appendix D, Page D-8.

Table 4. Example of Firing Schedule for Tank, 240-km/600-round, Cal .50 Machine Gun
(Commander's station) Test.

<u>Cycle No.</u>	<u>Vehicle Position</u>	<u>No.</u>	<u>Burst Length</u>	<u>Firing Trigger</u>	<u>Gun Elevation</u>
1	Level	1	20	C	0
		2	20	C	Min
		3	20	C	0
		4	20	C	Max
		5	20	C	0
2	Pitch Forward 30°	1	20	C	0
		2	20	C	Min
		3	20	C	0
		4	20	C	Max
		5	20	C	0
3	Pitch Rearward 30°	1	20	C	0
		2	20	C	Min
		3	20	C	0
		4	20	C	Max
		5	20	C	0
4	Cant Left 15°	1	20	C	0
		2	20	C	Min
		3	20	C	0
		4	20	C	Max
		5	20	C	0
5	Cant Right 15°	1	20	C	0
		2	20	C	Min
		3	20	C	0
		4	20	C	Max
		5	20	C	0
6	Level	1	20	C	0
		2	20	C	Min
		3	20	C	0
		4	20	C	Max
		5	20	C	0

- NOTES: 1. Run 40 kilometers before each firing cycle for a total of 240 kilometers.
2. All firings are with the gun forward over the front of the vehicle.
3. When the vehicle is pitched rearward, limit maximum gun-turret elevation to 30 degrees for a total elevation of 60 degrees.
4. Codes and abbreviations are listed at Appendix D, Page D-8.

Table 5. Example of Firing Schedule for Abrams Tank System, 240km/1,200-round 7.62-mm Loader's Machine Gun (Skate/Ring Mounted) Test.

<u>Cycle No.</u>	<u>Vehicle Position</u>	<u>No.</u>	<u>Burst Length</u>	<u>Firing Trigger</u>	<u>Gun Elevation</u>
1	Level	1	25	L	0
		2	25	L	Min
		3	25	L	0
		4	25	L	Max
		5	25	L	0
		6	25	L	Min
		7	25	L	0
		8	25	L	Max
2	Pitch Forward 30°	1	25	L	0
		2	25	L	Min
		3	25	L	0
		4	25	L	Max
		5	25	L	0
		6	25	L	Min
		7	25	L	0
		8	25	L	Max
3	Pitch Rearward 30°	1	25	L	0
		2	25	L	Min
		3	25	L	0
		4	25	L	Max
		5	25	L	0
		6	25	L	Min
		7	25	L	0
		8	25	L	Max
4	Cant Left 15°	1	25	L	0
		2	25	L	Min
		3	25	L	0
		4	25	L	Max
		5	25	L	0
		6	25	L	Min
		7	25	L	0
		8	25	L	Max
5	Cant Right 15°	1	25	L	0
		2	25	L	Min
		3	25	L	0
		4	25	L	Max
		5	25	L	0
		6	25	L	Min
		7	25	L	0
		8	25	L	Max

Table 5. Example of Firing Schedule for Abrams Tank System, 240km/1,200-round 7.62-mm Loader's Machine Gun (Skate/Ring Mounted) Test. (cont'd.)

<u>Cycle No.</u>	<u>Vehicle Position</u>	<u>No.</u>	<u>Burst Length</u>	<u>Firing Trigger</u>	<u>Gun Elevation</u>
6	Level	1	25	L	0
		2	25	L	Min
		3	25	L	0
		4	25	L	Max
		5	25	L	0
		6	25	L	Min
		7	25	L	0
		8	25	L	Max

- NOTES: 1. Run 40 kilometers before each firing cycle for a total of 240 kilometers.
 2. All firings are with the gun forward over the front of the vehicle.
 3. When the vehicle is pitched rearward, limit maximum gun-turret elevation to 30 degrees for a total elevation of 60 degrees.
 4. Codes and abbreviations are listed at Appendix D, Page D-8.

Table 6. Example of Firing Schedule for 240km/360-round 5.56mm Firing Port Weapon Test (M231).

<u>Cycle No.</u>	<u>Vehicle Position</u>	<u>No.</u>	<u>Burst Length</u>	<u>Firing Trigger</u>	<u>Gun Elevation</u>
1	Level	1	20	1	Min
		2	10		0
		3	20	2	Max
		4	10		0
2	Pitch Forward 30°	1	20	1	Min
		2	10		0
		3	20	2	Max
		4	10		0
3	Pitch Rearward 30°	1	20	1	Min
		2	10		0
		3	20	2	Max
		4	10		0
4	Cant Left 15°	1	20	1	Min
		2	10		0
		3	20	2	Max
		4	10		0
5	Cant Right 15°	1	20	1	Min
		2	10		0
		3	20	2	Max
		4	10		0
6	Level	1	20	1	Min
		2	10		0
		3	20	2	Max
		4	10		0

- NOTES: 1. Run 40 kilometers before each firing cycle for a total of 240 kilometers.
 2. All firings are with the gun forward over the front of the vehicle.
 3. When the vehicle is pitched rearward, limit maximum gun-turret elevation to 30 degrees for a total elevation of 60 degrees.
 4. Codes and abbreviations are listed at Appendix D, Page D-8.

5. DATA REQUIRED.

- a. Record and describe all malfunctions. Identify malfunctions using standard codes and determine cause, particularly in reference to adverse effects of sand and dust IAW the firing record example in Appendix B. Guidance and rationale for analysis of malfunctions relative to the influence of sand and dust contamination is contained in Appendix C. A list of malfunction codes can be found at the end of Table 7 and also Appendix D.
- b. Record times for all scheduled and unscheduled maintenance actions for comparison with tasks performed under non-sand and dust conditions.
- c. Measure and record significantly increased operating efforts of: latches/locks; gun charging; moving elevation and azimuth screws; removing and installing of gun and mount pins; and operating manual safety and trigger. Use torque wrenches and push-pull scales, as required.
- d. Record the gunner's/commander's target obscuration observations by landolt ring gap position related to ring size and target distance. This will provide a measurement of the smallest space the gunner's/commander's eye can detect between the parts of a "real" target.
- e. Record ambient temperature, humidity, barometric pressure, wind velocity and wind direction.
- f. Record distance of travel, engine operating time, turret and turret stabilization operating time.
- g. Record all weapon subsystems, vehicle model number and serial numbers. Ensure any changes or modifications are adequately described. Prepare firing record sheets for round-by-round data as shown in Appendix B, record previous rounds fired, and enter pertinent information for each burst/cycle to be fired. Use a working test schedule/plan for guidance derived from the approved test plan as shown in example Tables 1 through 6.
- h. Prepare and submit Test Incident Reports (TIR's) on test incidents occurring during the test as prescribed by DA Pam 73-1⁶.

6. DATA REDUCTION AND PRESENTATION.

- a. Combine the firing record example (Appendix B) with the applicable firing schedules from example Tables 1 through 6 to produce round-by-round data which will be included as an Appendix in the test report. Examples of round-by-round data for a test of M2 Bradley IFV Weapons Systems are contained in Appendix D.

b. If there is a massive amount of malfunction data, it may prove useful to make a list of malfunctions which can include somewhat less detail than the round-by-round data but more than can be included in a summary of malfunctions. An example is contained in Appendix D.

c. Condense and summarize malfunctions from the round-by-round data as shown in Table 7. This table also includes the results of analysis of each type of malfunction as to whether or not they are sand and dust related and whether or not the subsystems in the various test scenarios (phases), iterations, and test runs met or did not meet the system criterion.

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Table 7. Summary of Results.

Weapon System	Stoppages	Clearing Time	Other	Attributed to	Sand/Dust Related	Criteria Met/ Not Met	Remarks
Clean Function Firing							
25 mm	2 FSO 1 FX		1 FMR	2 PER 1 GUN 1 GCS	NA	Met	
7.62-mm	0		0			Met	
5.56-mm No. 21	0		0			Met	
5.56-mm No. 39	0		0			Met	
5.56-mm No. 52	0		0		NA	Met	
Test Profile*: Scenario No. 1; Iteration No.1; Test Run No. 1							
25-mm	0		1 FMR	1 GUN	N	Met	
7.62-mm	2 FFO 1 FSO	00:04:00		1 FSC 1 PER 1 GCS	Y NA Y	Not Met	
5.56-mm No. 21	0		1 FBR	1 GUN	N	Met	
5.56-mm No. 39	1 FJ	00:01:00		1 CES	N	Not Met	
5.56-mm No. 52	0		0		NA	Met	
Test Profile: Scenario No. 1; Iteration No. 1; Test Run No. 2							
25-mm	2DML		0 1 FMR	2 GCS 1 GCS	Y N	Met	
7.62	1 FFR 2 FF 1 FSO 1 FFO 1 FFO	00:04:00 00:11:00 00:05:00		1 FSC 2 PER 1 FAC 1 FSC 1 FSC	Y NA NA Y Y	Not Met	
5.56-mm No. 21	0		0		NA	Met	
5.56-mm No. 39	0		0		NA	Met	

Weapon System	Stoppages	Clearing Time	Other	Attributed to	Sand/Dust Related	Criteria Met/Not Met	Remarks
5.56-mm No. 52	0		0		NA	Met	Cleaned guns, ammo, feed chutes, and boxes.
*Test Profile was determined by the following parameters; Scenario No. 1 run out of dust. Scenario No. 2 run in dust. Iteration total 50 miles (two 25-mile runs), then clean. Test run 25-mile run, fire after run, two each.							
Test Profile: Scenario No. 1; Iteration No. 3; Test Run No. 2							
25-mm			2 FMR	2 GCS	N	Met	
7.62-mm	1 FF 6 FFR	00:01:36 00:01:00 to 00:01:36	6 FSC	1 FSC Y	Y	Not met	
5.56-mm No. 21	0		0	4 GUN	NA	Met	Replaced bolt assembly with one from Gun No. 21
5.56-mm No. 39	4FX		1 FRA 0	1 CES	Y	Not met	
5.56-mm No. 52	0				NA	Met	

LEGEND:

General	Malfunction	Malfunction Attribution
Ammo - Ammunition	DML - Drive malfunction light	CES - Fired case ejection system
N - No	FBC - Failure of bolt to close	DER - Derivative, caused by a primary failure
NA - Not Applicable	FBR - Failure of bolt to latch to rear	FAC - Test facility support
Y - Yes	FE - Failure to elevate	FSC - Feed System, chuting
Assy - assembly	FF - Failure to feed round forward	GSC - Gun electrical/electronic control system
	FFO - Failure to feed round over to ram position	GUN - Gun
	FMT - Feeder malfunction light	PER - Personnel error
	FRA - Failure to remain in assembly	REP - Repetitive
	FSM - Failure to select mode	THD - Turret mechanical drive
	FSO - Failure of bolt to sear off	TSE - Turret Supplemental equipment
	FSU - Failure to sear up	UNK - unknown
	FX - Failure to extract	
	FFR - Failure to fire	
	FJ - Failure to eject	
	FMR - Failure to maintain cyclic rate	
	IFR - Inadvertent firing control system	
	PS - Partial strip of round from link	

APPENDIX A. PREPARATION FOR TEST CHECKLIST.

Specific areas and points to inspect as applicable, are:

1. Lubrication (IAW applicable TM or LO instructions).
2. Adequate electrical power for externally powered guns and/or firing solenoids.
3. Fit of covers for gun, feed chutes and boxes, barrel muzzle, and sight system.
4. Function of fans and ventilators.
5. Function of manual and power operated turret controls, and range of elevation and depression.
6. Function of ancillary and auxiliary equipment such as doors, hatches, seat adjustments, turret/travel lock, locks and hold open devices, and safety belts.
7. Function of fire control system, including firing interrupters for hatches, gun safety, etc.
8. Function of stabilization system; electronic controls for firing modes, cyclic rate, and feed selects; range finder; cant corrector; wind sensor; etc.
9. Function of gun mount zeroing mechanism or electronic synchronization.
10. Operation of skate mount on tracks, including brake and lock.
11. Function of sight controls and operation of night sight and covers/shields.
12. Function of gun charger.
13. Ease of mounting and dismounting gun, and changing of barrel.
14. Function of ammunition ready box rollers, hinges, and latches.
15. Ease of removal and installation of ammunition feed and ejection chutes.
16. Function of ammunition box stowage racks retaining bracket straps or latches.
17. Function of stowed weapon rack locks or straps.
18. Ensure all covers and plugs are in place.

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19. Ensure track shrouds/shields are down.
20. Ensure all electrical connectors are in place and tight.

APPENDIX B. DATA COLLECTION SHEET.

Firing Record Example for BFVs Test

Time	Cycle	No. Rounds Fired	On Gun	Mal- func	Remarks
Test Phase No. 2, Iteration No. 1, Test Run No. 2					

Date:
Range Clearance.: 20
IFV M2 No. 436
Firing Clearance No: 22
25-mm M242 Auto Gun No. 172, TPT Ammo Lot No. PFC82B126-002
0800 Started Vehicle Run 2742 od.km.
0910 Completed Vehicle Run 2782 od.km

		Vehicle Level		
0930	2	5	832/	OK
		10		OK
		10		OK
		3	FFO	Bolt stopped 1/2 inch into feed sector. Round caught while being transferred from the feed sprocket to the rotor. Round was tipped forward. Base caught in groove in feeder rear plate assembly. Could not hand crank forward or rearward. Pushed front round stop out of the way with a screw driver, then it backed up to sear position OK. Tried again. TTC- 6 times.
		2		OK
		10		OK
		6	FX	Bolt stopped in extract position. Ammunition belt free, two empty links between round being fed and link chute interface were tight and binding in feeder strippers. Links in link chute were free. Hand cranked to sear position after freeing links with screwdriver.
1015		4	/881	OK Cleared gun and prepared for next run.

NOTE: As used with Table 1 Firing Schedule.

APPENDIX C. ANALYSIS OF MALFUNCTIONS.

Perhaps the most crucial determination to be made is that of the effects of sand and dust accumulation on automatic and machine gun belt feed system performance. Belt-fed guns are particularly vulnerable to a sand and dust environment. They have separate openings for the ammunition belt and for link ejection, as well as fired cases, even when a cover is provided. Characteristically, each contaminated linked-round carries its own load of sand and dust into the gun, much like a conveyor belt.

Automatic and machine guns selected for vehicular use are presumed to have passed sand and dust tests on a test stand (see TOP 3-2-045). However, these tests are conducted with practically no belt feed load, as they are intended to evaluate basic gun performance alone. Vehicular ammunition feed systems are often marginal in performance, or just work under "normal" or moderate conditions. Thus, a marginal feed system can require all or nearly all of a particular clean gun's belt pull capacity (for belt pull capacity test). Therefore, the cumulative effects of sand and dust in feed chute, adaptor, sprockets, forwarders and ammunition boxes can result in greater feed loads than a clean gun is capable of pulling. This is aggravated by the expected reduction in belt pull capacity of the gun alone due to the effects of sand and dust in its mechanism. It can be assumed that in sand and dust conditions, the gun will not be able to pull the weight achieved in its standard belt pull test.

With self-powered guns, failure to feed over type stoppages are exemplified by a round not fully pulled over to the ram or stripping position; the bolt having been stopped short in its rearward travel; or the belt feed pawls having slipped off the round being fed over, allowing the belt to snap back and the bolt to close on an empty chamber. With external-powered guns, failure to feed over type stoppages are exemplified by links stretching so that the distance between linked rounds becomes excessive. This results in the set of feed sprocket arms behind the set feeding over a round, not being able to reach the next round, or the gun may simply stall. This condition can be aggravated by any resistance to links being ejected from the feeder into and through link chutes. Links binding in the feeder, on the other hand, may be the primary cause of stoppages.

Ammunition belt drag can also cause stoppages other than simple failures to feed over. They range from failures to feed (forward), partial strips of rounds from links, through failures to fire due to light firing blows on the cartridge primer. These occur as a result of binding of the bolt in self-powered guns when it attempts to move forward and feed a round out of the link into the chamber. If the round is not fully seated in the slot or ram position, the round will bind and the operating spring lacks sufficient energy to complete the cycle with adequate force. Bolt binding can also occur through resistance from the overloaded belt feed lever during travel, depending on its design.

Firing failures can also occur as a result of sand and dust contamination acting on the bolt assembly firing mechanism alone. Contamination can also cause failure to extract fired cases from the barrel chamber. Hard extraction may result in bolt short recoil or travel, producing failures to eject. The

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bolt may carry the fired case back into the chamber or the bolt may come back only far enough to produce a partial ejection of the case.

A system sand and dust test such as this can be more severe on the gun alone than the test stand tests. This is possible because of the protracted firing and running to which the system is subjected. The sand and dust has more opportunity to work its way further into the gun mechanism than is the case in a test stand application.

APPENDIX D. LIST OF MALFUNCTIONS AND ROUND-BY-ROUND DATA.

List of Sand and Dust Malfunctions

Weapon System	Rounds on Gun	Malfunction			Attributed to	Remarks
		Stoppages	Clearing Time	Other		
			Clean Function Firing			
25 mm	3276 3282	2 FSO FX			2 PER Gun GCS	Feeder out of time. Bolt stopped on misfire. Last two rounds fired at HI rate, when set on LO.
7.62-mm	65	0		FMR	0	
5.56-mm No. 21	2790	0			0	
5.56-mm No. 39	2740	0			0	
5.56-mm No. 52	60	0			0	
Test Profile*: Scenario No. 1; Iteration No. 1; Test Run No. 1						
25-mm	3228			FMR	Gun	Two rounds fired on LO, when set on SS.
7.62-mm	92 92 94	2 FFO FSO		0	1 FSC 1 PER GCS	Belt dragging over chute adaptor. Trigger did not actuate.
5.56-mm No. 21	2820		00:04:00	FBR	Gun	Insufficient spring tension or short recall.
5.56-mm No. 39	2761	FJ	00:01:00	0	CES	Case spinback from case catcher.
5.56-mm No. 52	120	0		0		
Test Profile: Scenario No. 1; Iteration No. 1; Test Run No. 2						
25-mm	3391 3408	2DML		0	GCS GCS	Turned power off and on, and elevated and depressed to clear. First three rounds fired SS, when set on LO.
7.62-mm	140 140 140	FFR 2 FF FSO	00:04:00 00:11:00		FSC 2 PER FAC	Bolt slowed by misaligned round in feedway, belt dragging. Round left in receiver from previous FFR. No test.
	168 173	FFO FFO	00:05:00		FSB FSC	Belt binding in box. Set gas port to No. 2
5.56-mm No. 21	2910	0		0		
5.56-mm No. 39	2860	0		0		
5.56-mm No. 52	180	0		0		
Guns, feed chutes, and ammo boxes cleaned. Installed APG modified 5.56-mm case catcher bag..						

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APPENDIX D. LIST OF MALFUNCTIONS AND ROUND-BY-ROUND DATA.

Weapon System	Rounds on Gun	Malfunction			Remarks
		Stoppages	Clearing Time	Attributed to	
5.56-mm No. 52	3440			FRA	Gun fell out of its mounting bracket during run
5.56-mm No. 21	3445			TSE	Two fired cases fell out of bag.
5.56-mm No. 39	3350	FF		CES	Stubbed round.
	3363	FX		Gun	Extracted fired case with charger handle.
	3368				Possibly weak extractor spring; no replacement on hand
	3377				Installed bolt assembly from Gun No. 21 at 3384.
	3383				
	3384				
	3350	FX		Gun	Case catcher bag retaining pin washer fell off.
	3350			CES	Magazine latch hit bag bracket, causing magazine to disengage.
	3370	FRA		FRA	
	3371	FRA		CES	Replaced extractor and spring in bolt and reinstalled original bolt assemblies in guns No.21 and 39
5.56-mm No. 52	720	0		0	
Test Profile: Scenario No. 1; Iteration No. 3; Test Run No. 2					
25-mm	3968			FMR	Fired one round after trigger was released. Occurred while holding low ammo
	3970			GCS	override button down. This may be a design characteristic.
7.62-mm	901			GCS	
	909	FF	00:01:36	FSC	Bolt slowed by misaligned round in feedway due to belt dragging over chute adaptor
	914	FFR		FSC	LB. Bolt slowed by misaligned round in feedway due to belt dragging over chute adaptor.
	915				
	916		00:01:36		Lubricated bolt ways and feed cover assembly.
	928		00:01:00		LB. Bolt slowed by misaligned round in feedway due to belt dragging over chute adaptor.
	929	FFR		FSC	
5.56-mm No. 21	3416	0		0	
5.56-mm No. 39	3441	FX		Gun	Extracted fired case with charger handle.
	3442				
	3443	FX		Gun	Replaced bolt assembly with one from Gun No. 21
	3416			CES	Case catcher bag retaining pin washer fell off.
*Test Profile was determined by the following parameters; Scenario No. 1 run out of dust. Scenario No. 2 run in dust. Iteration total 50 miles (two 25-mile runs), then clean. Test run 25-mile after run, two each.					

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Round-by-Round Data for Test Conducted at Mile Post 70, Sand and Dust Course/Range

Time (MST)	Cycle Burst No.	Test Rounds		Feed	Mode	Trig- ger	Elev	Malfunctions				Remarks
		Burst in	on Gun					Mal- func- tion	Relevant Component	Cause of Malfunction/Failure	Attri- buted to	
Function Firing												
25-mm Gun, No. 827, Feeder No. 843, Barrel No. 2419*												
Ammunition Lots NO.: TPT M793:HJA83J154-005, APDST M791:PFC83K009-022												
Date 31 May 1984												
1417	1	0	3276/ 3275	AP	SS	RHG	Min	FSO	Feeder	Unknown	UNK	No power to drive. Checked gun connector, OK.
1424		0	3276					FSO	Feeder	Indicator moved 1/8 inch. Vertical feed shaft out of time.	PER	Feeder out of time
Date: 1 June 1984												
NOTE: Removed feeder, checked bolt position for timing, took slack out of butterfly knob. Reassembled and timed. Dry cycled. No commander's trigger, removed connector and reattached, then OK.												
0951		5	3277/							OK		
	2	1	3282	HE	LO	LHG	0°	FX	Bolt	Stopped at misfire	Gun	Brought to sear with trigger.
		9	3291					FMR	Unknown	Unknown	Gun	Last two rounds fired on HI rate.
	3	10		HE	HI	MG	Max					
	4	5		AP	SS	C	Max					
	5	10		HE	LO	RHG	0°					
	6	10	/3326	HE	HI	LHG	Min					

* The feeder strippers were checked with feeler gages. The largest combination that would pass through all four strippers was 0.062 inch.

* The feeder strippers were checked with feeler gages. The largest combination that would pass through all four strippers was 0.062 inch.

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Time (MST)	Cycle Burst No.	Test Rounds		Feed	Mode	Trig- ger	Malfunctions					Remarks
		Burst in	on Gun				Elev	Mal- func- tion	Relevant Component	Cause of Malfunction/Failure	Attri- buted to	
7.62-mm Gun No. U39443												
Ammunition Lot: 4 Ball M80, 1 Trac M62:LCL-139210												
Note: Bushing for solenoid bracket bolt in grip was missing. Had to get one from another gun. In interim fired FPW's.												
5.56-mm Weapon No. 21-RR												
Ammunition Lot: Trac M196:TW18199												
1016	1	20	2731/	M1 A			Min	OK				
	2	10					0°	OK				
	3	20		M2 A			Max	OK				
	4	10	/2790				0°	OK				
5.56-mm Weapon No. 39-RF												
	1	20	2681/	M3			Min	OK				Vehicle: 2524 km.
	2	10					0°	OK				
	3	20		M4			Max	OK				
	4	10	/2740				0°	OK				
5.56-mm Weapon No. 52-RF												
	1	20	1/	M5			Min	OK				
	2	10					0°	OK				
	3	20		M6			Max	OK				
	4	10	/60				0°	OK				
Date: 6 June 1984												

Vehicle: 2524 km.

Time (MST)	Cycle Burst No.	Test Rounds		Feed Gun	Mode	Trig-ger	Elev	Malfunctions			Remarks
		in	on					Mal-func-tion	Relevant Component	Cause of Malfunction/Failure	
0854	Started run - 2614 km, 187.7 turret hours										
0950	Blower on - 2639 km, 189.1 turret hours										
	Completed run - 2658 km										
Test Profile: Scenario No. 2, in dust cloud; Iteration No. 1; Distance 44 km											
0959	1	2	3428/3429	AP	SS	RHG	Min	FMR	Unknown	Unknown	Unk Fired second round Hi rate reselected.
1005	2	10	LO	HE	LHG	0°	OK	DML	Turret Control Box	Unknown	GCS Turned power off and on
								FMR	Unknown	Unknown	Unk Fired two rounds Hi rate. Checked all connections. Time to clear 6 minutes from start.
1005	3	3	3444	HE	HI	MG	Max	FX	Bolt assy	Stopped in misfire position	Gun Turned power off, handcranked minutes and 6 seconds.
								FSO	Unknown	Unknown	Have sear light. Time to clear 4 minutes and 6 seconds.
1005	0	3445	FX	Bolt assy	Stopped in misfire position	Gun	Heard a round or fired case drop out ejection port. Time to clear 4 minutes and 6 seconds.				
0957 1119	3	3446	FX	Bolt assy	Stopped in misfire position	Gun	Brought to sear position electrically. Time to clear 4 minutes and 6 seconds.				
0957 1119	3	3450	FX	Bolt assy	Stopped in misfire position	FAC	See following FSU. Time to clear 4 minutes and 6 seconds.				
Test Profile: Scenario No. 1; Iteration No. 1; Test Run No. 1; Distance 38 km											
0957 1119	Started test run - 2903 km, 197.5 turret hours										
	Completed test run - 2942 km, 199.9 turret hours										

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Time (MST)	Cycle Burst No.	Test Rounds		Feed	Mode	Trig- ger	Elev	Malfunctions			Remarks	
		Burst in	on Gun					Mal- func- tion	Relevant Component	Cause of Malfunction/Failure		Attri- buted to
1214	1	5	3842/	AP	SS	RHG	Min	OK	25-mm Gun			Vehicle clock hours: 2942 km
	2	10	3856	HE	LO	LHG	0°	DML	Unknown	Unknown	GCS	Turned power off for 4 minutes and 22 seconds, and turned back on, OK.
	3	10	3866	HE	HI	MG	Max	OK				
	4	3	3869	AP	SS	C	Max	FX	Bolt assy	Stopped in misfire position	Gun	Brought to sear electrically.
	2							FSM	Feed selection	Unknown		No sear light, then it went on, but then feeder mal- function light went on, then off. Could not select feed. Solenoid chatters going to AP LO. Handranked HE side to drop round stop. Manual feed select knob binding. Cranked HE side again and knob freed. Time to clear 10 minutes.
1230	5	0	3871	HE	LO	RHG	0°	FX	Bolt assy	Stopped misfire position	Gun	Brought bolt to sear position electrically. Time to clear 2 minutes.
		0	3871					FX	Bolt assy	Stopped misfire position	Gun	Brought bolt to sear position electrically. Handranked ammo belt at forwarder, belt OK and feeder as well. Links binding in strippers. Time to clear 3 minutes.
		10						OK				
1234	6	10	/3891	HE	HI	LHG	Min	OK				
	5	10				RHG	0°	OK				
	6	10	/954			LHG	Min	OK	5.56-mm No. 21-RR			

Time (MST)	Cycle Burst No.	Test Rounds			Trig- ger Mode	Elev	Malfunctions			
		Burst	in	on			Mal- func- tion	Relevant Component	Cause of Malfunction/Failure	Attri- buted to
1241	1	20	3451/	M1 A		Min	Ok			
	2	10				O°	OK			
	3	20		M2 A		Max	OK			
	4	10	/3510			O°	OK			
										Used remaining case catcher bag retaining pin washer from FPW No. 21.
										5.56-mm No. 39-RF
1245	1	20	3396/	M3			OK			
	2	1	3416				FX	Extractor	Slipped off rim of fired case	Gun
							FRA	Fired case pin bag pin washer	Fell off	CES
1247		9					OK			
	3	16	3441	M4			FX	Extractor	Slipped off rim of fired case	Gun
		1	3442				FX	Extractor	Slipped off rim of fired case	Gun
1249		1	3443				FX	Extractor	Slipped off rim of fired case	Gun
	2	10	/3455				OK			Extracted fired case using charger handle. Installed bolt assembly from gun No. 21
	4	10					OK			

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General	Malfaction	Attribution
AIL - Authorized Item List	DML - Drive malfunction light	CES - Fired case ejection system
Ammo - Ammunition	FBC - Failure of bolt to close	DER - Derivative, caused by a primary failure
AP - Armor Piercing	FBR - Failure of bolt to latch to rear	FAC - Test facility support equipment
APDST - Armor Pierc. Disc. Sabot Tracer	FE - Failure to elevate	FSB - Feed System, ammo box
APG - U.S. Army Aberdeen Proving Ground	FF - Failure to feed round forward	FSC - Feed System, chuting
Assy - assembly	FFO - Failure to feed round over to run position	GCS - Gun electrical/electronic control system
BII - Basic Issue Items	FFR - Failure to fire	Gun - Gun
BFVS - Bradley Fighting Vehicle System	FI - Failure to eject	PER - Personnel error
C - Commander's	FMR - Failure to maintain cyclic rate setting (mode)	REP - Repetitive
C/B - Cycle/Burst No.	FMT - Feeder malfunction light	TMD - Turret mechanical drive system
CIL - Clean, inspect, and lubricate	FRA - Failure to remain in assembly	TSE - Turret Supplemental equipment
F - Fail	FSM - Failure to select mode	UNK - unknown
FAA - Federal Aviation Administration	FSO - Failure of bolt to seat off	
FMC - Food Machinery Corp	FSU - Failure to seat up	
FPW - Firing port weapon	FX - Failure to extract	
G - Gunner	IFR - Inadvertent firing control system	
GM - Gunner's Manual (firing trigger)	PS - Partial strip of round from link	
HE - High Explosive		
HHL - Hughes Helicopter, Inc.		

M1A	M2A	M3	M4	M5	M6
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M2A

MG - Manual gunner's trigger

Max. - Maximum

Min - Minimum

N - No

NA - Not Applicable

O - Zero degree elevation

P - Pass

PMO - Project Manager's Office

RHG - Right hand gunner's trigger

S&D - Sand and Dust

SS - Single shot

STE - Simplified Test Equipment

TDB - Turret Distribution Box

TPT - Target Practice Tracer

USMC - I

Y - Yes

APPENDIX E. REFERENCES.

1. TOP 2-4-001, Desert Environmental Testing of Wheeled and Tracked Vehicles, 12 May 1969.
2. TOP 1-1-006, Desert Environmental Considerations, 10 August 1972.
3. TOP 2-2-819, Wheeled and Tracked Vehicle Air Cleaner Testing Adequacy, 31 January 1989.
4. TOP 2-4-002, Arctic Environmental Test of Tracked and Wheeled Vehicles, 10 July 1969.
5. TOP 3-2-045, Automatic Weapons, Machine Guns, Hand and Shoulder Weapons, 21 December 1983.
6. DA Pam 73-1, Test and Evaluation Guidelines, Chapter 17, 16 October 1992.

Forward comments, recommended changes, or any pertinent data which may be of use in improving this publication to one of the following addresses: Technology Management Division, (CSTE-DTC-TT-M), US Army Developmental Test Command, 314 Longs Corner Road, Aberdeen Proving Ground, MD 21005-5055. Technical information may be obtained from the preparing activity: Natural Environments Test Office (CSTE-DTC-YP-NE), US Army Yuma Proving Ground, 301 C Street, Yuma Proving Ground, AZ 85365-9124. Additional copies are available from the Defense Technical Information Center, 8725 John J. Kingman Rd., STE 0944, Fort Belvoir, VA 22060-6218. This document is identified by the accession number (AD No.) printed on the first page.